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Study of Exhaust Emissions from Thirty Five High Mileage 1979 Passenger Cars

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Ann Arbor, MI

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A Study of Exhaust Emissions from Thirty Five High Mileage 1979 Passenger Cars

by

John C. Shelton

September 1983

Test and Evaluation Branch
Emission Control Technology Division
Office of Mobile Sources
U.S. Environmental Protection Agency

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16. ABSTRACT

This paper describes the results of an exhaust emission testing program conducted on thirty-five 1979 passenger cars. The primary purpose of this program was to examine the emission performance of high-mileage vehicles. Secondary objectives included an assessment of the condition and performance of the emission-related components and adjustments and information for development and improvement of I/M programs. The work was performed by Automotive Testing Laboratories (ATL) at the Transportation Research Center in East Liberty, Ohio.

The test vehicles were drawn from the general public in the Columbus, Ohio area using direct mail solicitation. Only vehicles with over 75,000 miles were sought. This resulted in an average odometer reading for the fleet of 87,000. The tests performed included the Federal Test Procedure, the Highway Fuel Economy Test and several short tests. The program began in December 1982 and was completed in May, 1983.

The results of this program indicate that these vehicles are capable of maintaining low emission levels although high levels are also possible due to emission control component failure, engine wear, deterioration and tampering.

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ABSTRACT

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The results of this program indicate that these vehicles are capable of maintaining low emission levels although high levels are also possible due to emission control component failure, engine wear, deterioration and tampering. The average emission test results were significantly higher than the standards under which they were certified and somewhat higher than the averages of comparable in-use vehicles at lower mileages. City and Highway fuel economy values were also found to be lower than those published in the 1979 Gas Mileage Guide.

Introduction

Few data are currently available on late model, in-use vehicles beyond the 50,000 mile "useful life" defined by Federal Regulations. Because approximately half of the passenger cars registered today have passed that point, this category of vehicles has a significant impact on ambient air quality. In this project, emission data were collected on a sample of 1979 model year vehicles which have exceeded 75,000 odometer miles. The test results will be used to support estimates of future emission levels from vehicles with this type of control technology.

Purpose

The purpose of this program was three-fold:

1. To gather advanced information on high mileage vehicles in order to better predict future emissions from vehicles which have accumulated mileage at a more normal rate.

2. To identify weaknesses and potential failure areas in emission control systems so that the effectiveness of the regulatory process can be enhanced.

3. To provide information for development and improvement of inspection/maintenance programs.

Program Design

This work was performed by Automotive Testing Laboratories (ATL) at the Transportation Research Center of Ohio under EPA Contract No. 68-03-3157. Thirty-five vehicles of the 1979 model year with over 75,000 miles were sought at random from a direct mailing. The vehicles selected were in customer use and were tested "as-received" in order to reflect differences in usage, maintenance and repair. Names and addresses of owners of 1979 model year passenger cars in the area of Columbus, Ohio were purchased from R.L. Polk Co. Solicitation packages were mailed to 2000 owners at random. The package included a letter and a postpaid reply card with which an owner could report certain vehicle information and express his willingness to participate. A copy of this package is included as Appendix A. Since we were seeking vehicles with the highest mileage, ATL ranked the positive responses by odometer reading. No attempt was made to procure a sample which represented national sales. Owners of vehicles with the highest readings were contacted and offered an incentive package consisting of a $100 Savings Bond, a loan car and a full tank of fuel upon return of their vehicle. ATL also offered to exchange cars at the owner's convenience and promised a summary of the test results on their vehicle.

At the initial meeting, the principal driver was asked to complete a short questionnaire and fill out several forms related to the exchange of vehicles. Examples of these are included as Appendix B.

Once each vehicle was acquired, an ATL technician prepared it for testing. Fluid levels were checked and corrected but no other underhood activities were conducted. A sample of the drained fuel was analyzed for lead content. Preconditioning consisted of the first 505 seconds of the Federal Driving Cycle on the dynamometer or driving for 10 minutes on city streets. This was followed by a 12-24 hour soak period.

Each vehicle was tested as-received in the following sequence:

1. Federal Test Procedure (without heat-build or measurement of evaporative emissions).

2. "Bagged Idle" test. During this three minute idle test the exhaust emissions are gathered through the CVS. The FTP instruments are used to analyze the diluted sample.

3. "50 MPH Cruise" Test. This short cycle employs garage instruments to measure tailpipe concentrations of HC and CO during the 50 mph preconditioning for the HFET.

4. Highway Fuel Economy Test.

5. Four-Mode Idle Test. This short test is comprised of four steady state modes: Idle in neutral, 2500 rpm in neutral, idle in neutral, and idle in drive. Garage instruments are used to sample tailpipe concentrations of HC and CO for each mode.

6. Loaded Two-Mode Test. Sampling is done as before using garage instruments. The first mode is 30 mph at 9 actual dynamometer horsepower. The second mode is idle in neutral.

7. Restart Idle Test. This idle test consists of two operating modes. At the end of the 6-minute idle period, the engine is shut off. The vehicle is immediately restarted using the hot-start procedure and the engine is brought up to 2500 rpm ($\pm$300 rpm). Emissions are measured within 30 seconds. The engine is then returned to idle neutral and idle emissions are measured within 30 seconds. Garage instruments are used to sample tailpipe concentrations of HC and CO for each mode.

8. A complete underhood inspection was performed after the emission tests.

The FTP and HFET data are used for comparison with certified emission levels and to help project future levels of air quality due to vehicles of the 1979 model year. The inspections and short cycles provide information for development and improvement of Inspection/Maintenance programs.

Results

The program began in December, 1982. It was conducted sucessfully in accordance with the design and was completed in May, 1983.

Of the 2000 solicitation packages sent out, responses were received from 703 owners. This total of 35 percent was somewhat lower than the approximately 50 percent experienced in similar programs. We attributed this difference to the text of the letter which indicated our primary interest in high mileage vehicles. No follow-ups, either by mail or phone, were part of the plan.

Figure 1 displays the number and type of responses versus time. Over 85 percent of the responses were received within nine days of the mailing. Of the total responses, 56 percent indicated a willingness to participate in our program although only five percent were both willing and able to participate. All acceptable vehicles with over 75,000 miles were tested with an average odometer reading for the fleet of 87,000.

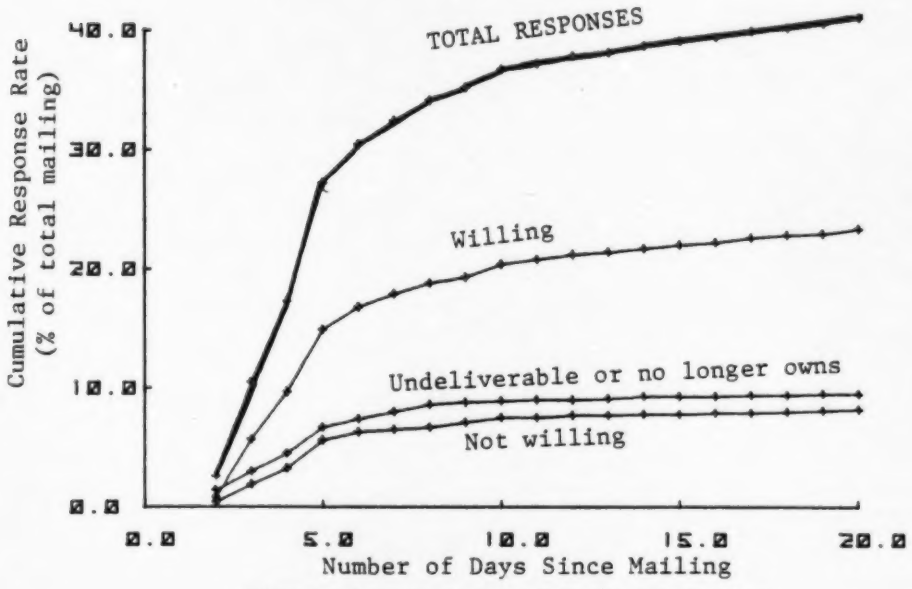

Figure 1. Response Rate Versus Time

Although no attempt was made to procure a sample which represented national sales, the fleet tested reasonably reflected the national population for the 1979 model year. While there were some shortages of Fords, Toyotas and miscellaneous imports and an over-representation of Datsuns, these were probably due to the relative strengths of dealers in the Columbus area. Table 1 presents the sample share versus the market share.

Table 1
Sample Share versus Market Share (1979 Model Year)

	Sample	Market
General Motors	54%	47%
Ford	12	20
Chrysler	11	9
AMC	3	2
Datsun	11	4
Honda	6	3
Audi	3	1
Toyota	0	5
Misc. Imports	0	9
	100%	100%

Emission Test Results

A summary of the results from the FTP and HFET tests are shown in Table 2. FTP and HFET results for each vehicle are attached as Appendix C. FTP results for individual pollutants are displayed in ranked order in Figures 2 through 4.

Table 2
Average Test Results versus Standards

			FTP Emissions				Fuel Economy			
									% of Guide	
	N	Odom	HC	CO	NOx	% Pass	FTP	HFET	FTP	HFET
This program	35	87,239	2.76	24.1	2.94	14	16.4	22.7	93	97
Stds/Guide	-	-	1.5	15.0	2.0	100	-	-	100	100

Note: Emission results are in grams per mile, fuel economy is in miles per gallon.

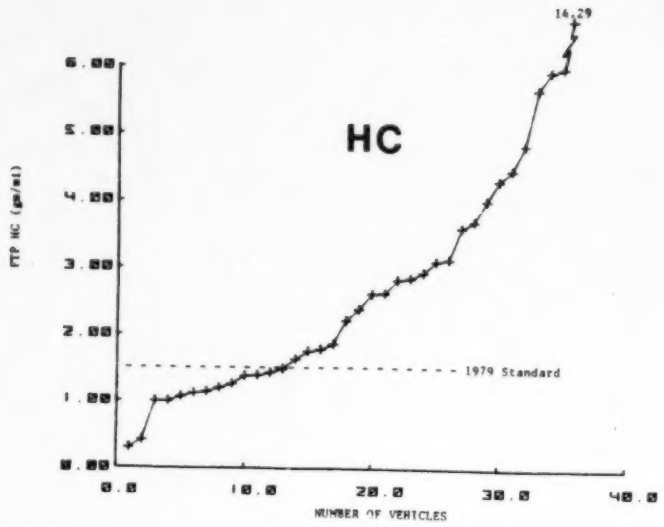

Figure 2. FTP HC Levels in Ascending Order

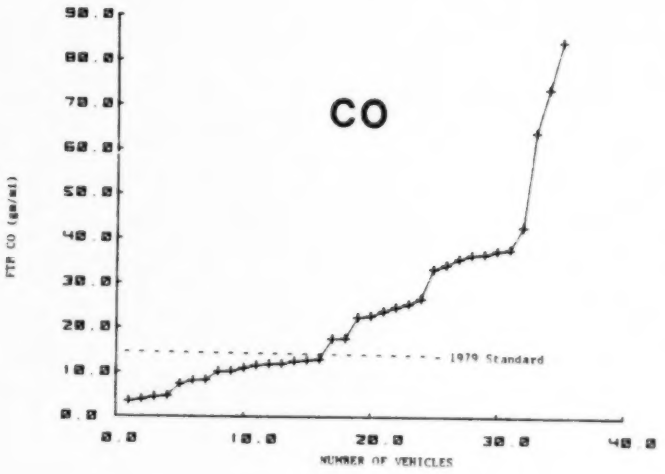

Figure 3. FTP CO Levels in Ascending Order

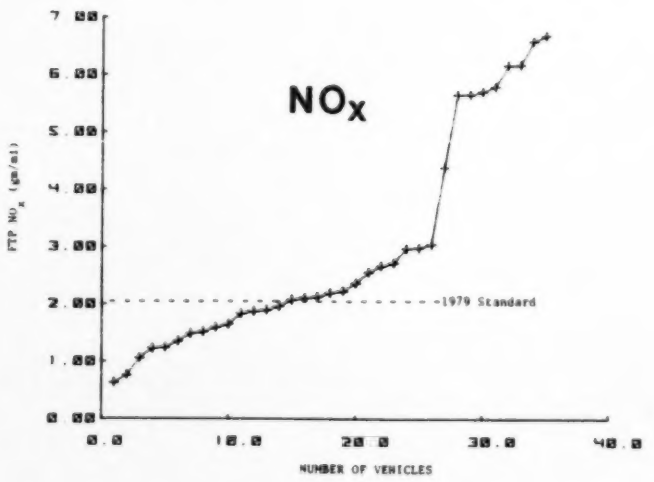

Figure 4. FTP NOx Levels in Ascending Order

Miles-per-gallon (mpg) figures for both the FTP and HFET were calculated. The average fuel economy was compared to the appropriate values listed in EPA's 1979 Gas Mileage Guide. Figures 5 and 6 are histograms of fuel economy as a percent of guide value. The distribution of the values appear to be reasonable and consistent with the results of earlier work. Vehicle #104, a Chevette, appears in the lowest cell of each figure but we could not determine a reason for the atypical shortfall.

Idle Emissions

Shown in Figures 7 and 8 are plots of FTP emission levels versus results of a basic idle test. As can be expected, there was a reasonable correlation between results of the FTP and the results of the idle test. Using the typical cutpoints of 250 ppm for HC and 2.5% for CO, the chart in Figure 9 displays the number of correct predictions in addition to errors of omission. There were no errors of commission. Thus, it appears that such a test is applicable to vehicles at higher as well as lower mileages.

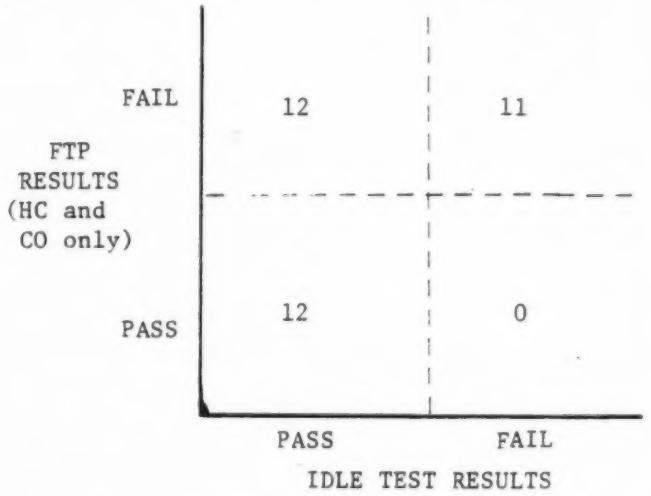

Figure 9. Comparison of FTP and Idle Test Results

Underhood Inspection

Each of the vehicles was tested in "as-received" condition to gather data representative of the population. An underhood inspection of emission related components and adjustments was also conducted to evaluate the degree of any maladjustments, disablements, inadequate maintenance, defects, unusual deterioration or misbuilds. Any abnormal physical condition or a measured value outside an allowable range was coded as a failure.

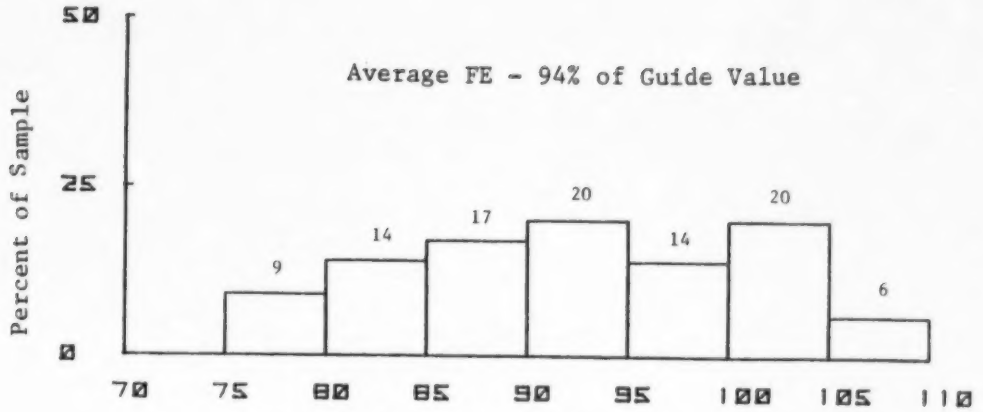

Figure 5. Histogram of FTP Fuel Economy Values

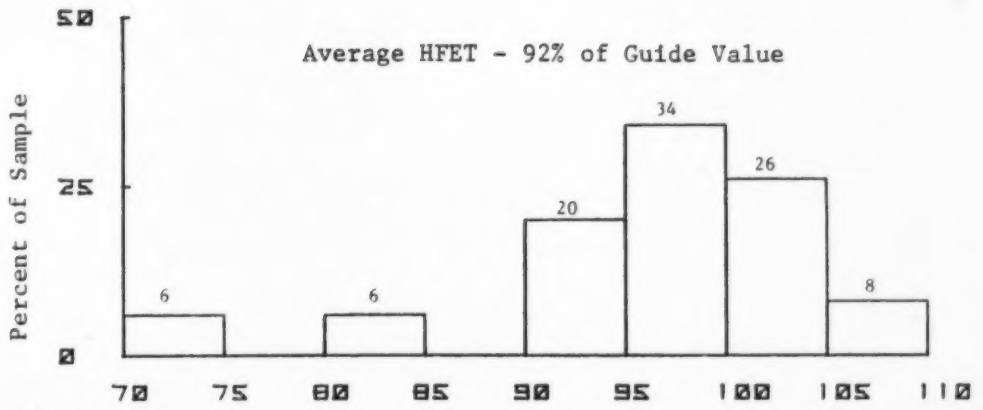

Figure 6. Histogram of HFET Fuel Economy Values

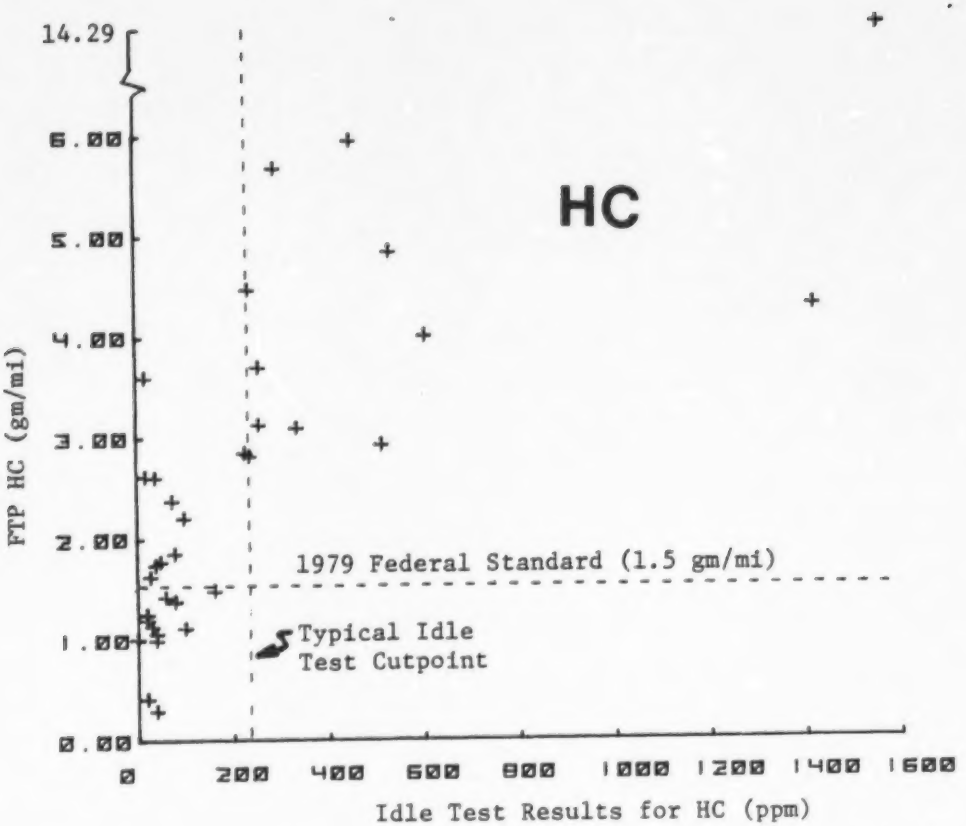

Figure 7. Results of Idle Test Versus FTP Values for HC

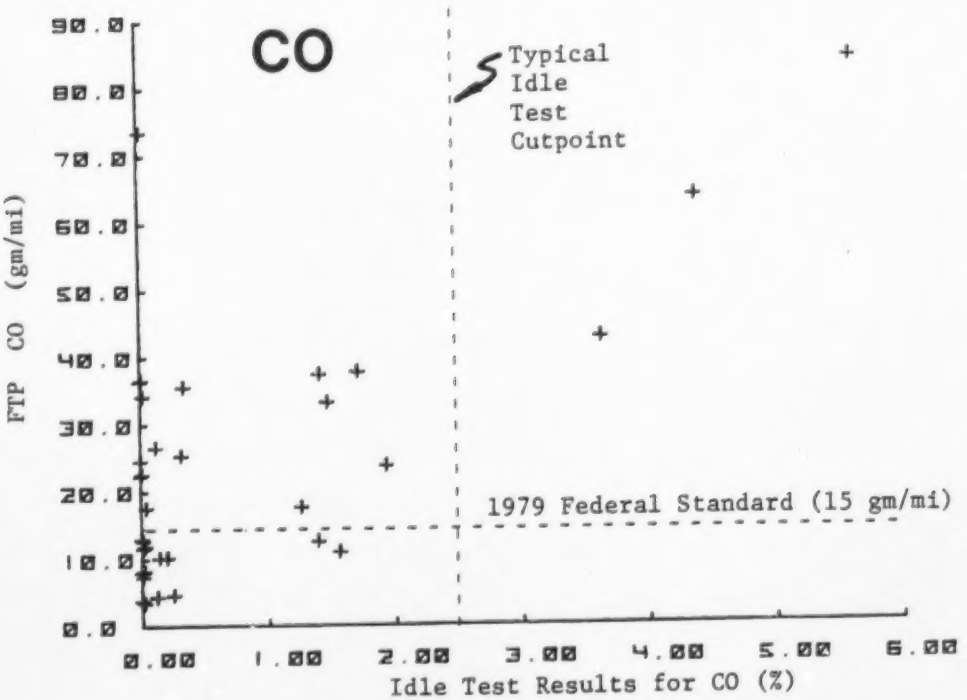

Figure 8. Results of Idle Test Versus FTP Values for CO

While results from past programs have shown that vehicles which are in proper operating order generally produce the lowest emission levels, none of the vehicles in this effort were found to be in proper order. A summary of these findings is contained in Appendix D. Typical problems include idle mixture adjustment, basic timing, idle speed, choke settings and EGR tampering. Although no clear evaluations are possible, we have identified nine of the highest emitters and discussed the possible reasons for their failure. These are listed in Appendix E.

Misfueling

Fuel samples were drawn from each of the vehicles and examined for lead content. In addition, filler necks were examined and the PLUMBTESMO test was conducted. Only one vehicle (#126) which required the use of unleaded fuel was found to show signs of using leaded fuel. This was not considered unusual in that the proportion of all vehicles which have been misfueled would not be properly represented in a voluntary program sponsored by EPA. The only filler neck which was found to be altered was also on #126. Although HC emissions on this vehicle were very high, CO emissions were below the standard. It appears that ignition deficiencies and other problems may have masked the effects of the misfueling alone. The PLUMBTESMO tests correctly identified all eight vehicles which were using leaded fuel and did not fail any which were not.

Comparison With Results of Other Programs

EPA has conducted several test programs which sampled comparable 1979 models. During these earlier programs, 221 vehicles from the 1979 model year were tested. The average mileage for this sample was 11,400 miles. Of this sample, almost half met their standard with average HC and NO_x levels below the standard. Average CO emissions slightly exceeded the standard. These results are listed in Table 3 and are plotted in Figures 10-12.

Other results were obtained from a program known as EF-I. This program included 43 vehicles from the 1979 model year which were tested at EPA's Ann Arbor facility. A random sample drawn from within 20 miles of Ann Arbor was obtained using the State of Michigan registration list. The first 43 acceptable vehicles were tested. The testing was completed in October 1982. Results from this program are also listed in Table 3 and plotted in Figures 10-12.

As can be seen from Tables 2 and 3, the average emission levels of these vehicles show a definite trend toward higher levels as the vehicles accumulate mileage. Without restorative maintenance, the cause for these differences cannot be attributed precisely to deterioration of the engine or simply problems with the control systems.

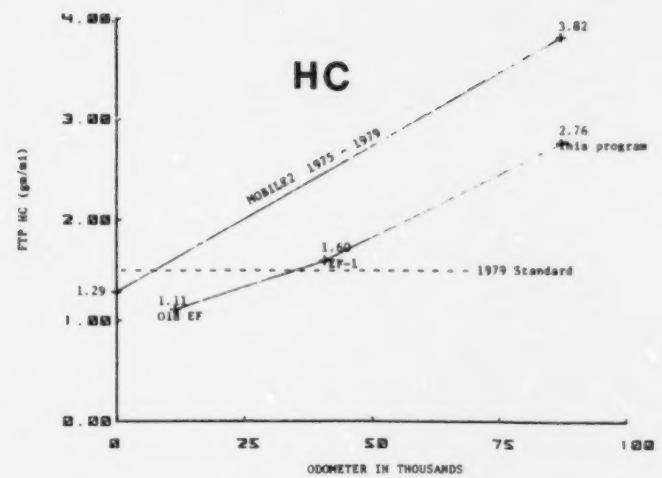

Figure 10. Relationship of Average HC Levels to Odometer Reading

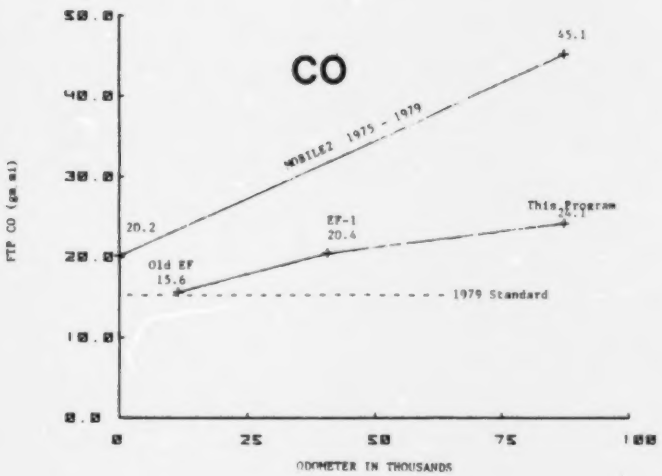

Figure 11. Relationship of Average CO Levels to Odometer Reading

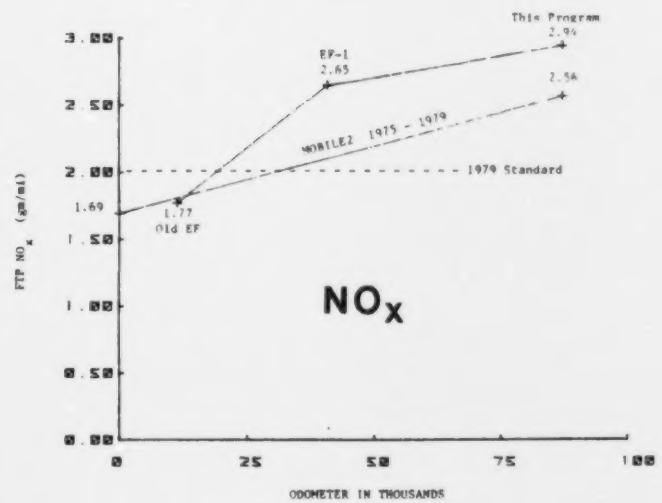

Figure 12. Relationship of Average NOx Levels to Odometer Reading

Table 3
Average Test Results From Three Sources
of Emission Factor Data

			FTP			%	Fuel Economy	
	N	Odom	HC	CO	NOx	Pass	FTP	HFET
Earlier EF	211	11,400	1.11	15.6	1.77	47	-	-
EF-1	43	40,800	1.60	20.4	2.65	30	99	-
This program	35	87,200	2.76	24.1	2.94	14	93	97

Note: Emission results are in grams per mile, fuel economy is in percent of Guide Value.

Comparison with MOBILE2 Projections

According to the information contained in Figures 10, 11, and 12, MOBILE2 is overestimating HC and CO emissions and slightly underestimating NO_x emissions for the 1979 model year vehicles at higher mileage. One reason for this may be due to the fact that MOBILE2 groups 1975-79 models together. As a result, it does not generally assume that the fleet is equipped with sealed idle mixture screws. However, all GM vehicles in these samples were so equipped. This feature has been found to greatly reduce the aggregate HC and CO levels by preventing casual misadjustment of the mixture. Another reason for the difference may be that these vehicles have accumulated their mileage at an accelerated rate (approximately 35,000 per year) and therefore, have not encountered as much deterioration due to aging as vehicles with normal mileage accumulation. On the other hand, interviews with the participants indicated that a number of the vehicles are no longer their primary one and now receive less scheduled maintenance.

Conclusions

The results of this program indicate that these vehicles are capable of maintaining low emission levels although high levels are also possible due to emission control component failure, engine wear, deterioration and tampering. The average emission test results of these high-mileage 1979 models were significantly higher than those resulting from the EPA Certification. Considering the results from other studies on 1979 models at lower mileage, there is also a clear trend toward increasing emission levels with age, mileage and the associated degradation of components and adjustments. On the other hand, the actual HC and CO emissions (at least for this model year) were significantly lower than predicted by the MOBILE2 model while the NO_x emissions were slightly higher. City and Highway fuel economy values were also found to be lower than those published in the 1979 Gas Mileage Guide.

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
and
Automotive Testing Laboratories, Inc.
P.O. Box 289
East Liberty, Ohio 43319

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P.O. Box 289
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☐ Yes, I am interested in this program.

Odometer reading _____ miles
(Please fill in odometer reading)

☐ Sorry, I have chosen not to participate.

☐ I would like more information.

☐ I no longer own a 1979 or 1980 vehicle.

Telephone _____ Best time to call _____

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

OFFICE OF
AIR, NOISE AND RADIATION

Dear Vehicle Owner:

The Environmental Protection Agency is conducting an important air pollution study. The actual work will be performed under contract by Automotive Testing Laboratories (ATL) at the Transportation Research Center of Ohio. You have been selected as a possible participant in this program, in which an official EPA fuel economy and emissions test would be performed on your vehicle. You may be able to help us and be rewarded for your cooperation.

Our current program involves testing 1979 and 1980 vehicles with high odometer readings. If your vehicle qualifies, we will offer you the following incentives to participate:

1. The use of a late-model, fully insured loaner car with a full tank of fuel. We will exchange vehicles at a time and place of your choice.
2. A $100 U.S. Savings Bond.
3. Return of your vehicle with a full tank of fuel.
4. The results of the emission and fuel economy tests.

No unusual operations will be performed on your vehicle and it will be fully insured for the entire test period, which will take approximately one week. If you are willing to participate, a representative of ATL will be in touch with you to ask questions about your vehicle.

Please complete and return the enclosed postpaid reply card as soon as possible, even if you choose not to participate or if your odometer reading is not high. Other programs are planned for which you may be eligible.

The enclosed information sheet answers questions people often ask about this program. If you have any additional questions, please feel free to call Priscilla Bruce of ATL at 221-0336 or John Shelton of my staff at (313) 668-4200. They will be able to answer any questions you may have.

We look forward to receiving your reply card or a telephone call very soon.

Sincerely,

Ralph C Stahman

Ralph C. Stahman, Chief
Test and Evaluation Branch

Enclosures

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

MOTOR VEHICLE EMISSION TESTING PROGRAMS

OFFICE OF
AIR, NOISE AND RADIATION

Questions and Answers

1. **Must I participate in this program?**

   No, your cooperation in this program is completely voluntary. If, for any reason, you decide not to participate, please let us know on the enclosed postpaid reply card.

2. **Why should I participate?**

   In addition to a $100.00 U.S. Savings Bond, a loaner vehicle and a full tank of gasoline, your participation will benefit you indirectly by helping EPA understand and improve the quality of the air in and around your city.

3. **How long will the test program take?**

   The test program takes approximately 1 week. The length of time is dependent on how many other cars are being tested.

4. **Will my vehicle be mistreated in any way?**

   No, every aspect of the test program has been designed to duplicate everyday operation.

5. **Exactly what will be done to my vehicle?**

   A complete underhood inspection will be performed. The vehicle must be commpletely cooled off before the test can begin. This requires that the vehicle not be started for 12 to 36 hours to simulate overnight parking. Once the vehicle is sufficiently cooled off, it will be pushed onto a dynamometer. Although the vehicle doesn't actually move during the test, the dynamometer is a type of treadmill which simulates conditions which would normally be encountered on the road. A hose is connected to the exhaust pipe to collect the exhaust. A specially trained driver then starts the vehicle and "drives" it through a "driving cycle" which represents typical operation in urban, suburban and rural areas. Throughout this time, a portion of the exhaust gases is collected for subsequent exhaust analysis. This analysis allows us to calculate the quantity of exhaust emissions emitted by your vehicle. Values for the city and highway fuel economy are also calculated.

(over)

6. How many miles will my vehicle be driven during the program?

Your vehicle will be driven approximately 100 odometer miles during the testing. The majority of these miles will be accumulated indoors on the dynamometer. A 10 minute road test might precede the dynamometer testing.

7. How will my vehicle be protected while in your possession?

In addition to providing insurance, we will store your vehicle indoors while the testing is being conducted. If required to be parked outside, your vehicle will be located in a locked and secure area at ATL's Motor Vehicle Emission Laboratory which is located at the Ohio Transportation Research Center in East Liberty, Ohio.

8. What happens to the information obtained from my vehicle?

The information collected as a result of this program is used to determine the emissions performance of in-use vehicles and its effect on air quality. The data from your vehicle are combined with data from other vehicles in this area in order to obtain a statistically valid sample.

9. How can I obtain the results from the testing of my vehicle?

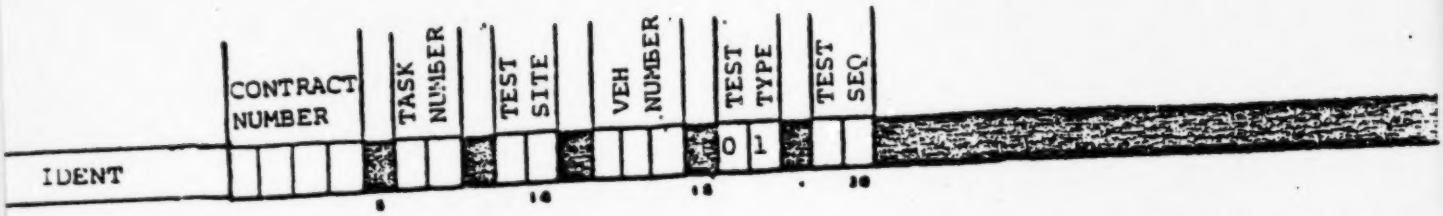
If you request, after the completion of the testing you can obtain the results on your vehicle. We will forward them to you as soon as all the data have been processed.

10. What happens if my vehicle fails to meet any emission standards?

We expect that a certain proportion of the vehicles will fail to meet one or more of the emission standards. However, none of the information collected from this program will be used against individual vehicle owners.

VEHICLE OWNER QUESTIONNAIRE
DATA SHEET

APPENDIX B



1) What is the brand name of the fuel you normally use (see list below)?	
2) Have you, or others, ever noticed a hydrogen sulfide (rotten eggs) odor in the vehicle exhaust?	1 (never) 2 (seldom) 3 (occasionally) 4 (frequently) 5 (don't know)
3) Have you ever used gasohol in this vehicle?	1 (never) 2 (seldom) 3 (occasionally) 4 (frequently) 5 (don't know)
4) If you have used gasohol, a) Have you noticed any difference in the vehicle performance?	1 (never used gasohol) 2 (perf. is better) 3 (perf. is worse) 4 (no difference) 5 (don't know)
b) Have you noticed any difference in fuel economy?	1 (never used gasohol) 2 (fuel economy better) 3 (fuel economy worse) 4 (no difference) 5 (don't know)
5) How long ago did you purchase the vehicle to be tested?	1 (0-3 months) 2 (3-12 months) 3 (1-2 years) 4 (over 2 years)

DATA ENTRIES FOR QUESTION #1

ENTER	BRAND NAME	ENTER	BRAND NAME	ENTER	BRAND NAME	ENTER	BRAND NAME	ENTER	BRAND NAME	ENTER	BRAND NAME
AMOC	AMOCO	CLAR	CLARK	FINA	FINA	MOBI	MOBIL	SHEL	SHELL	UNIO	UNION
ARCO	ARCO	CONO	CONOCO	GEMC	GEMCO	MOTO	MOTOR	SINC	SINCLAIR	VICK	VICKERS
ASHL	ASHLAND	CROW	CROWN	GULF	GULF	PENN	PENNEYS	SITE	SITE	WARD	WARDS
BONA	BONAFIDE	DERB	DERBY	HESS	HESS	PHIL	PHILLIPS	SKEL	SKELLY	ZEPH	ZEPHYR
BP	BP	ENCO	ENCO	HUDS	HUDSON	SCOT	SCOTT	STAN	STANDARD	**	OTHER
CHEV	CHEVRON	ESSO	ESSO	MARS	MARS	SEAR	SEARS	SUNO	SUNOCO	UNKN	UNKNOWN
CITC	CITCO	EXXO	EXXON	MART	MARTIN	SHAM	SHAMROCK	TEXA	TEXACO	VARI	VARIOUS

** IF BRAND IS 'OTHER', THEN ENTER THE FULL BRAND NAME VEHICLE OWNER USES.

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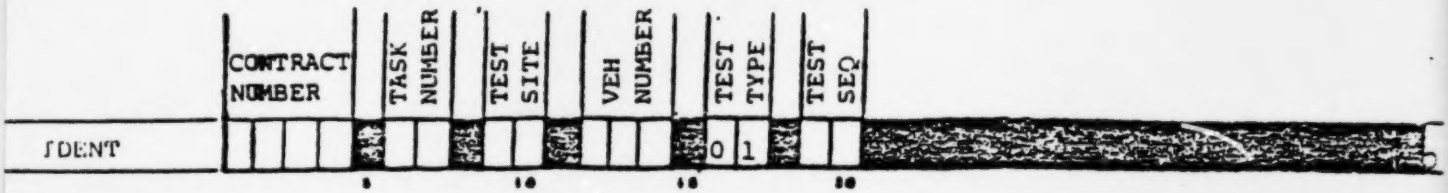
VEHICLE OWNER QUESTIONNAIRE
DATA SHEET



6) On a yearly basis, how many thousands of miles is this vehicle driven?		1 (0-5) 2 (5-10) 3 (10-15) 4 (15-20) 5 (20-30) 6 (over 30)	(10
7) Where is the driving done? almost all: > 75% most: 75-51% some: 50-21% little or none: < 20%	a) City expressways	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(11
	b) Major city streets	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(12
	c) Other city streets	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(13
	d) Rural expressways	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(14
	e) Other rural roads	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(15
8) How is the driving done? almost all: > 75% most: 75-51% some: 50-21% little or none: < 20%	a) To and from work	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(16)
	b) Shopping and errands	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(17)
	c) Business (not to and from work)	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(18)
	d) Other (social, vacations, etc.)	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(19)
9) How did you get here today?		1 (city streets only) 2 (some expressway) 3 (primarily expressways)	(20)
	Approx. miles	☐☐	(21-

VEHICLE OWNER QUESTIONNAIRE
DATA SHEET

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ
IDENT					0 1	
	5		10	15		20

10) How is this vehicle used? almost all: > 75% most: 75–51% some: 50–21% little or none: < 20%	a) Driver only	1 (almost all) 2 (most) 3 (some) 4 (little or none)
	b) Driver and one passenger	1 (almost all) 2 (most) 3 (some) 4 (little or none)
	c) Driver and 2 or more passengers	1 (almost all) 2 (most) 3 (some) 4 (little or none)
	d) Driver only with heavy cargo	1 (almost all) 2 (most) 3 (some) 4 (little or none)
	e) Driver, passenger and cargo	1 (almost all) 2 (most) 3 (some) 4 (little or none)
	f) Towing a trailer	1 (almost all) 2 (most) 3 (some) 4 (little or none)
11) On a typical day, how many trips are made with this vehicle? (One trip is defined as starting the engine, traveling some distance and stopping the engine).		☐☐
12) On a weekly basis, how often is full throttle acceleration used?		1 (seldom) 2 (once or twice) 3 (3–6 times) 4 (every day)
13) Do you now experience any engine performance problems with this vehicle?	a) Hard starting	1 (yes) 2 (no)
	b) Stalling	1 (yes) 2 (no)
	c) Rough idle	1 (yes) 2 (no)
	d) Engine misfiring	1 (yes) 2 (no)
	e) Poor acceleration	1 (yes) 2 (no)
	f) Stumbling	1 (yes) 2 (no)
	g) Hesitation	1 (yes) 2 (no)
	h) Engine knock or ping	1 (yes) 2 (no)
	i) Dieseling (after run)	1 (yes) 2 (no)

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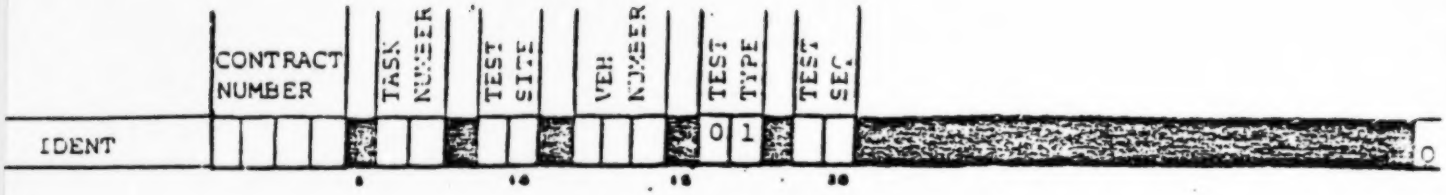
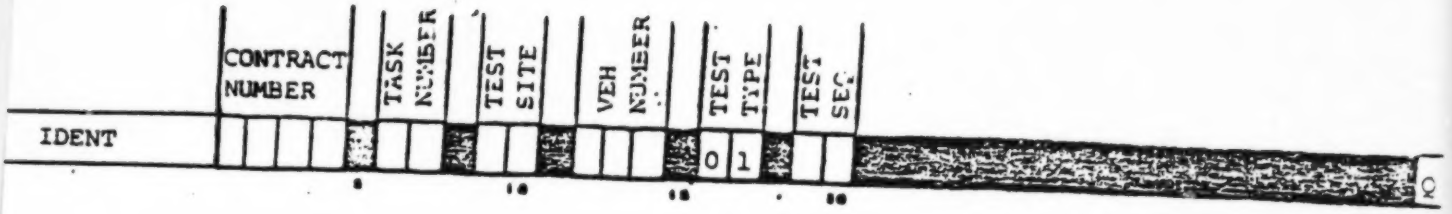
VEHICLE OWNER QUESTIONNAIRE
DATA SHEET



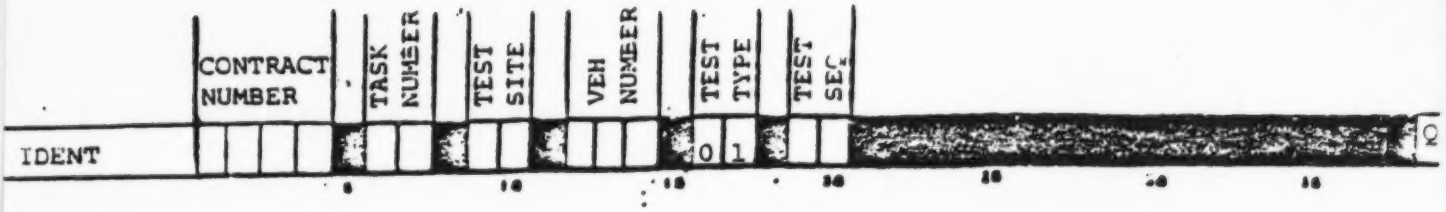
14)	Overall, are you reasonably satisfied with the engine performance of this vehicle?	1 (yes) 2 (most of the time) 3 (no) (41)
15)	How long ago was the last oil change?	1 (too new, not due) 2 (due, but not yet done) 3 (0-6 months ago) 4 (6-12 months ago) 5 (Over 1 year ago) 6 (don't know) (42)
16)	If you purchased the vehicle under warranty, how many times has it been returned for warranty repairs?	1 (no warranty) 2 (never returned) 3 (twice) 4 (3 or more) 5 (don't know) (43)
17)	What was the nature of the warranty repair?	1 (no warranty) 2 (never returned) 3 (recall) 4 (driveability) 5 (other) (44)
18)	Have you had any repairs to your vehicle for the correction of driveability problems?	1 (yes) 2 (no problems) (45)
19)	What repairs were performed on your vehicle to correct the driveability problems? Specify _____	1 (none) 2 (carburetor) 3 (engine) 4 (emission control system) 5 (ignition system) 6 (other) 7 (don't know) (46
20)	How long ago were these repairs accomplished?	1 (no repairs) 2 (0-3 months) 3 (3-6 months) 4 (over 6 months) 5 (don't know) (47
21)	Were these repairs effective in correcting the driveability problems?	1 (no repairs) 2 (yes) 3 (no) (48
22)	Is this vehicle operated regularly on unpaved roads, in competitive events, or in hauling or transporting loads heavier than for which it was designed?	1 (yes) 2 (no) 3 (don't know) (49

VEHICLE OWNER QUESTIONNAIRE
DATA SHEET



23) Has the vehicle ever had major damage in any of the following areas?	a) Engine	1 (yes) 2 (no)	(50
	b) Cooling system	1 (yes) 2 (no)	(51)
	c) Fuel system	1 (yes) 2 (no)	(52
	d) Exhaust system	1 (yes) 2 (no)	(53
	e) No damage	1 (yes) 2 (no)	(54
	f) Don't know	1 (yes) 2 (no)	(55
24) Has the catalytic converter ever been replaced on this vehicle?		1 (no catalyst) 2 (yes) 3 (no) 4 (don't know)	(56)
25) Was the vehicle tested in a previous EPA program?		1 (yes) 2 (no)	(57)
26) Has any maintenance performed since the last test?		1 (yes) 2 (no) 3 (not tested)	(5e
27) What type of maintenance was performed?		1 (warranty) 2 (tune-up) 3 (none) 4 (not tested)	(59
28) How much did the maintenance cost? 001 : no maintenance 002: don't know 003: not tested			(60-6
29) Who performed the maintenance?		1 (no maintenance) 2 (dealer) 3 (independent garage) 4 (tune-up clinic) 5 (yourself) 6 (not tested)	(6

VEHICLE OWNER QUESTIONNAIRE
DATA SHEET



30) Do you accurately keep records of the fuel economy on this vehicle?		1 (yes) 2 (no)
31) Are you concerned with the fuel economy of this vehicle?		1 (yes) 2 (no)
32) Date of last city or state emissions inspection. $\frac{99}{99}$: don't know $\frac{88}{88}$: not required $\frac{00}{00}$: never inspected	a) Month	
	b) Year	
33) Did your vehicle pass or fail the inspection?		1 (pass) 2 (fail) 3 (don't know) 4 (not required) 5 (never inspected)
34) a) Does your odometer indicate the true number of miles on your car?		1 (yes) 2 (no)
b) If no, specify approximate total number of miles this vehicle has been driven.		

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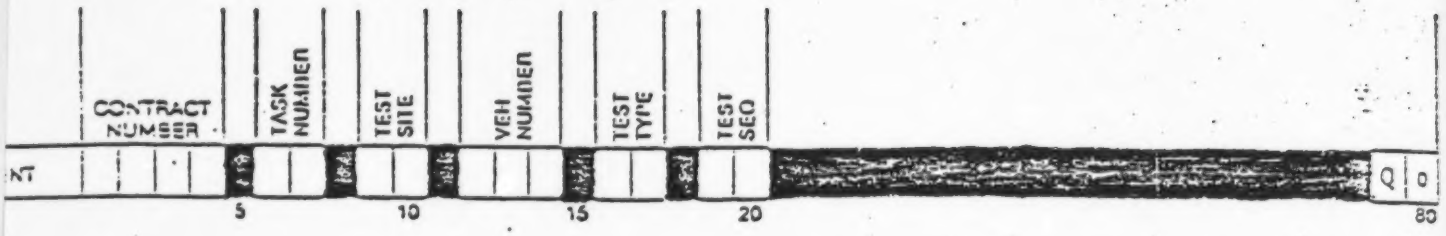
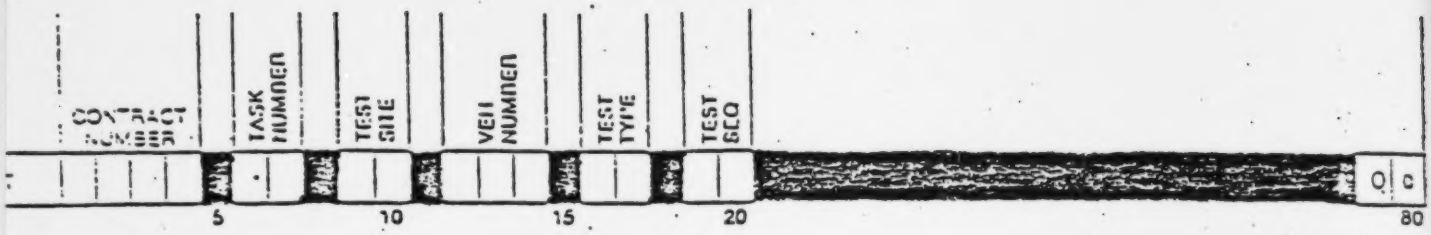


A)	How often is the car we are testing tuned up?	1 (at least every six) months) 2 (7 to 12 months) 3 (Less often than once per year) 4 (According to owners manual) 5 (Too new to be tuned) 6 ("When Needed") 7 (Other) 8 (Don't Know) 9 (Not Applicable)	(1)
B)	How long ago was the last tune up?	1 (6 months or less) 2 (7 to 12 months) 3 (longer than 12 months) 8 (Don't Know) 9 (Not Applicable)	(2)
C)	Who did the last tune up?	1 (car dealer) 2 (service station) 3 (independent garage) 4 (self or other family member) 7 (Other) 8 (Don't Know) 9 (Not Applicable)	(3)
D)	We are interested in the fuel economy people actually get with their cars. How many miles per gallon do you get with this car? (Enter "98" if Don't Know) (Enter "99" if Not Applicable)	a) in the city? ____ b) on the highway ____ c) combined city & highway	☐☐ (4-5) ☐☐ (6-7) ☐☐ (8-9)



E)	Has unleaded gasoline usually been used in this car?	1 (Yes) 2 (No) 8 (Don't Know) 9 (Not Applicable)	(10)
F)	Unleaded gas is more expensive than leaded and at times has been hard to find.	a) Have you ever used leaded gasoline in this car? b) If yes, how often?	1 (yes) 2 (no) 8 (don't know) 9 (Not Applicable) 50 (50 or more) 51 (Never) 52 (Seldom) 53 (Occasionally) 54 (Frequently) 99 (Don't Know or not Applicable)	(11) (12-13)

Q 12 1
80

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TEST NO.: F-8001 VEHICLE NO.: 279

CUSTOMER CONTRACT

NAME: Mr Thomas E Harron
ADDRESS: 151 Midgard Rd
CITY: Columbus STATE: OHio ZIP CODE: 43202
HOME PHONE: 268-2156 WORK PHONE: 1-800-323-0208
DATE/TIME-IN: _____ _____ DATE/TIME-OUT: _____

BOND INFORMATION

OWNER: Thomas Eugene Harron S.S. #: 291-48-2182
ADDRESS: 151 Midgard Rd
CITY: Columbus STATE: Ohio ZIP: 43202
CO-OWNER OR BENEFICIARY: Lisa L. Harron
NUMBER OF BONDS: 1 DENOMINATION: $100

OFFICE USE
PAGE_____
DATE_____
BY _____

VEHICLE INSPECTION

	OK	PAINT CHIPS	OTHER		OK	PAINT CHIPS	OTHER
LEFT REAR FENDER	✓			REAR END	✓		
LEFT DOORS	✓			REAR BUMPER	✓		
LEFT FRONT FENDER	✓			TOP	✓		
HOOD	✓			WINDOW GLASS	✓		
GRILL	✓			ANTENNA	✓		
FRONT BUMPER	✓			HUB CAPS	✓		
RIGHT FRONT FENDER	✓			MIRRORS	✓		
RIGHT DOORS	✓			INTERIOR	✓		
RIGHT REAR FENDER			Dent	TAPE DECK/CB	YES (NO)		
TRUNK LID	✓			LICENSE NO.	NEW 8 X 8		
BODY STYLE	2DR (4DR) SED WAG			TIRE MFR.	FIRESTONE		
VIN	2G3AR69A1B2411662			TIRE SIZE	P 195/75 R 14		
ODOMETER	67279 7			TIRE CONDITION	DON'T TEST ROTATE (OK)		
ENGINE FAMILY	14E2TM [illegible]			EXHAUST LEAK	DON'T TEST REPAIR (OK)		
CERTIFICATION	(FED) CAL ALT OTH			INSP. INITIALS	RE		

AMENDMENTS &/OR COMMENTS: _____
AGREED TO: 8-29 83 [DATE], BY JKH [INITIALS]

CONDITION WHEN RETURNED

ODOMETER: _____ DATE: _____
CONDITION: _____ INITIALS: _____

Automotive Testing Laboratories.Inc.
P.O. Box 289, East Liberty, OH 43319

PARTICIPANT VEHICLE NO. 279

VEHICLE EXCHANGE AGREEMENT

Automotive Testing Laboratories, Inc. (ATL) is furnishing you a Ford Fairmont (Model-Year) 1982 (Make, Model) Dan 134 (Lic.#) as a temporary substitute vehicle or a replacement for your Oldsmobile (Model-Year) Cutlass (Make, Model) MEW-844 (Lic.#) subject to the following terms and conditions:

You agree to be careful in the use of the loan vehicle and agree to return it to ATL within 7 days, together with all tires, tools and accessories and in as good interior, exterior and operating condition, normal wear and tear excepted, as when it was received by you.

You also agree that it will not be used to carry passengers or property for a consideration or to push or tow any vehicle or trailer. The loan vehicle will be operated only by you or a member of your immediate family provided that your permission is given and all such operators be at least 21 years of age and duly qualified and licensed.

You acknowledge personal liability for all charges, fines and costs for parking, traffic or other legal violations assessed against the loan vehicle while in your possession except where caused through fault of ATL; you further acknowledge liability for any allowable legal fees incurred by ATL collecting payment hereunder.

You agree to release and hold ATL harmless from any liability for loss of, or damage to, any property left, stored or transported in vehicle by you or any other person during or following the term of this agreement.

ATL, in turn, agrees to be fully responsible for any and all damage occurring to your vehicle while in ATL's possession. Such possession is hereby defined as care, control, custody, operation, inspection or storage between the time the vehicle is received from you and the time it is returned.

ATL also agrees to indemnify and hold you harmless of any repairs, damage, loss or liability sustained by you by reason of accident or damage to your vehicle while in ATL's possession.

ATL further agrees to be careful in the use of your vehicle and agrees to return it to you in as good interior, exterior and operating condition, normal wear and tear excepted, as when it was received by ATL.

In consideration of 100.00 Bond I agree to loan my vehicle to ATL for a time period not to exceed 7 days unless otherwise agreed to. I understand I am at liberty to demand the return of my vehicle at any time and that ATL is obligated to honor such and return my vehicle within a reasonable period of time regardless of the status of testing. If in the opinion of ATL my vehicle is unfit for testing, I waive consideration as specified above.

Agreed to this date, 8/21/85, by

Myron W. Gallogly and [signature]

Myron W. Gallogly, President — Vehicle Owner

Drivers lic. # I20I595 State OHIO Expires 5/87

PROJECT # 088-4

Appendix C
Testing of High Mileage 1979 Passenger Cars
Results of FTP and Highway Fuel Economy Tests

					FTP					HFET					Idle Test	
Veh.#	Make	Model	CID	Odometer Miles	HC	CO	NOx	F.E.	Guide	HC	CO	NOx	FE	Guide	HC	CO
101	Ford	LTD	302	87362	3.13	17.62	2.23	14.1	14	1.51	6.40	1.47	20.0	20	257	.04
102	Buick	Lesa	301	76720	1.00	7.38	2.13	16.2	17	0.20	0.45	3.16	22.3	24	39	.01
103	Olds	Delta	350	91587	14.29	23.76	2.97	12.1	16	4.57	2.56	3.66	16.2	22	1559	1.93
104	Chev	Chevette	98	107038	2.82	17.66	.63	21.7	29	0.45	4.94	0.60	28.8	40	237	1.26
105	Plym	Champ	98	81400	3.70	33.27	2.08	29.6	33	1.22	6.99	3.37	42.7	43	257	1.47
106	Audi	Fox	97	80457	1.07	4.43	1.90	24.0	23	0.58	2.02	2.42	37.6	37	39	.12
107	Pont	Bonn	301	113100	3.10	34.23	6.16	13.5	17	0.52	0.52	9.53	21.9	24	336	.02
108	Ford	LTD	302	83490	1.26	13.05	1.52	16.2	15	0.49	2.72	1.10	22.5	21	20	.00
109	Plym	Volare	225	86299	1.78	11.59	5.65	19.8	18	0.83	12.86	6.16	26.6	24	49	.01
110	Dats	510	119	90381	1.01	35.63	1.49	19.5	23	0.07	2.81	1.88	26.6	27	0	.34
111	Cadi	Deville	425	92800	1.12	11.86	4.38	12.2	14	0.22	0.60	3.31	19.9	20	99	.02
112	Chry	Newport	360	80486	4.85	22.43	1.23	12.7	14	0.93	3.58	1.80	21.7	22	533	.00
113	Dats	210	85	76838	1.86	25.41	3.04	22.7	27	1.16	16.52	4.88	31.3	38	79	.32
114	Dats	210	85	75745	1.39	10.23	1.97	27.4	28	0.89	2.84	3.16	39.8	39	79	.20
115	Pont	Bonn	301	78165	5.95	26.65	1.84	14.4	17	1.57	6.10	3.66	20.1	24	454	.12
116	Ford	LTD	302	75764	1.14	3.87	6.17	13.5	14	0.31	0.15	6.11	18.4	20	30	.00
117	Olds	Delta	260	77731	1.75	36.65	1.60	15.0	17	0.84	23.35	1.26	20.9	23	39	.01
118	Dats	210	85	77814	1.43	12.54	2.56	27.2	27	1.01	3.04	3.98	38.9	38	59	1.39
119	Chev	Monte	267	112282	3.60	73.52	.76	15.1	18	0.38	5.46	1.36	23.6	24	19	.02
120	Hond	Accord	107	85614	.42	4.66	1.88	25.4	26	0.02	0.49	1.99	36.2	35	20	.25
121	Olds	Cutlass	260	76274	1.38	8.12	2.37	16.4	19	0.37	0.24	3.11	24.1	25	79	.00
123	Ford	Fiesta	98	89373	.30	3.50	1.65	25.8	28	0.08	0.17	2.33	40.4	39	39	.02
124	Chev	Monte	200	147398	2.21	11.93	6.68	18.8	18	0.73	1.60	9.26	24.4	24	99	.03
125	Olds	Delta	350	77547	2.61	24.68	2.67	15.2	16	0.29	0.99	3.04	21.2	22	39	.00
126	Pont	Lemans	301	82298	4.31	10.18	5.70	18.1	18	1.81	1.80	7.38	25.2	24	1421	.14
127	Hond	Accord	107	80475	1.49	10.98	2.20	23.2	26	0.15	2.50	3.50	33.0	35	161	1.56
128	Olds	Cutlass	231	77283	1.20	8.26	6.58	17.7	19	0.25	0.71	8.44	24.9	25	20	.02
129	Chev	Impala	250	80349	2.93	42.77	2.10	15.5	15	0.71	6.50	2.76	22.4	22	513	3.63
130	AMC	Spirit	121	84493	4.47	63.79	2.72	19.8	22	1.68	13.90	5.07	30.5	33	237	4.38
131	Chry	Newport	360	107083	2.85	37.40	1.36	12.6	14	0.46	3.39	1.56	21.7	22	227	1.41
136	Chev	Camaro	350	92584	2.62	36.45	1.06	14.0	16	0.40	3.74	1.04	21.0	21	19	.00
137	Chev	Impala	305	80999	1.63	22.71	2.98	16.1	16	1.00	1.72	2.18	21.2	21	28	.01
143	Pont	Lemans	301	77081	4.01	37.74	5.65	16.6	17	0.81	2.66	8.30	22.4	24	606	1.71
145	Pont	Grand	231	78506	2.38	12.73	5.79	17.9	19	0.57	0.99	7.57	25.1	25	75	.01
149	Chev	Caprice	350	90552	5.68	84.18	1.25	13.6	14	1.21	14.46	1.29	19.8	18	294	5.61

NOTE: Exhaust emissions are in grams per mile while fuel economy is in miles per gallon. Results from the idle test are shown in ppm for HC and in % for CO.

Appendix D
Results of the Lead Tests and Underhood Inspection

VEH	PB.F	PB	INDT	FUEL	CHKE	IGNT	EGR	AIRP	PCV	EXHS	EVAP	MISC	TWAY
101	.012	PASS	FAIL	FAIL	FAIL	PASS	PASS	PASS	FAIL	PASS	FAIL	PASS	NA
102	.015	PASS	PASS	PASS	FAIL	FAIL	FAIL	NA	FAIL	PASS	PASS	PASS	NA
103	.007	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	NA	FAIL	FAIL	FAIL	FAIL	NA
104	.006	PASS	FAIL	FAIL	FAIL	FAIL	PASS	NA	PASS	PASS	PASS	PASS	NA
105	.018	PASS	FAIL	FAIL	PASS	FAIL	PASS	NA	FAIL	PASS	PASS	FAIL	NA
106	.100	FAIL	FAIL	FAIL	NA	FAIL	FAIL	NA	PASS	PASS	PASS	FAIL	NA
107	.007	PASS	FAIL	PASS	FAIL	PASS	FAIL	NA	PASS	PASS	FAIL	PASS	NA
108	.010	PASS	FAIL	FAIL	PASS	FAIL	FAIL	PASS	PASS	PASS	FAIL	PASS	NA
109	.010	PASS	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	PASS	PASS	FAIL	PASS	NA
110	.100	FAIL	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	FAIL	PASS	NA
111	.012	PASS	FAIL	PASS	FAIL	FAIL	FAIL	NA	FAIL	PASS	FAIL	PASS	NA
112	.019	PASS	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	PASS	PASS	FAIL	FAIL	NA
113	.100	FAIL	PASS	FAIL	PASS	PASS	FAIL	PASS	PASS	FAIL	FAIL	PASS	NA
114	.100	FAIL	FAIL	FAIL	PASS	FAIL	FAIL	PASS	FAIL	PASS	FAIL	PASS	NA
115	.012	PASS	FAIL	PASS	PASS	PASS	FAIL	NA	PASS	PASS	FAIL	PASS	NA
116	.004	PASS	PASS	PASS	FAIL	PASS	PASS	FAIL	FAIL	PASS	FAIL	PASS	NA
117	.004	PASS	PASS	FAIL	FAIL	PASS	FAIL	NA	FAIL	PASS	PASS	PASS	NA
118	.100	FAIL	PASS	FAIL	PASS	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	NA
119	.007	PASS	FAIL	FAIL	PASS	PASS	PASS	NA	FAIL	FAIL	PASS	FAIL	NA
120	.100	FAIL	FAIL	FAIL	PASS	FAIL	NA	NA	PASS	PASS	FAIL	PASS	NA
121	.009	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	NA	FAIL	PASS	FAIL	PASS	NA
123	.001	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	NA
124	.007	PASS	PASS	PASS	FAIL	FAIL	FAIL	NA	PASS	PASS	FAIL	PASS	NA
125	.012	PASS	FAIL	FAIL	FAIL	FAIL	PASS	NA	FAIL	PASS	FAIL	PASS	NA
126	.100	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	NA	FAIL	FAIL	FAIL	PASS	NA
127	.100	FAIL	PASS	FAIL	FAIL	PASS	NA	NA	PASS	PASS	PASS	PASS	NA
128	.035	PASS	FAIL	FAIL	FAIL	PASS	FAIL	NA	FAIL	PASS	FAIL	FAIL	NA
129	.001	PASS	PASS	FAIL	FAIL	FAIL	PASS	NA	PASS	PASS	FAIL	FAIL	NA
130	.005	PASS	PASS	FAIL	FAIL	FAIL	FAIL	PASS	FAIL	FAIL	FAIL	FAIL	NA
131	.001	PASS	FAIL	FAIL	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL	PASS	NA
135	.021	PASS	FAIL	FAIL	FAIL	PASS	PASS	FAIL	PASS	PASS	FAIL	PASS	NA
136	.004	PASS	PASS	FAIL	FAIL	FAIL	PASS	NA	FAIL	FAIL	FAIL	FAIL	NA
137	.001	PASS	PASS	PASS	FAIL	FAIL	PASS	NA	FAIL	FAIL	FAIL	PASS	NA
143	.015	PASS	PASS	PASS	FAIL	FAIL	FAIL	NA	FAIL	PASS	FAIL	PASS	NA
145	.015	PASS	PASS	PASS	FAIL	FAIL	FAIL	NA	FAIL	PASS	FAIL	PASS	NA
149	.017	PASS	PASS	FAIL	PASS	FAIL	PASS	NA	PASS	PASS	PASS	PASS	NA

Legend:

PBF	Lead content of as-received fuel (gm/gal)
PB	Results of Plumbtesmo test
INDT	Induction system (heated air door & temperature sensors)
FUEL	Fuel subsystem (carburetor, idle mixture, idle speed)
CHKE	Choke subsystem (choke adjustment and components, fast idle speed)
IGNT	Ignition system (distributor ass'y, initial timing, spark plugs)
EGR	EGR system (EGR valve ass'y, initial timing, spark plugs)
AIRP	Air injection system (air injection ass'y) valves, drive belt)
PCV	PVC system (PCV value, filter, hoses)
EXHS	Exhaust system (manifold, tailpipe, muffler, catalyst)
EVAP	Evaporative control system (canister, filter, hoses)
MISC	Engine Assembly (engine, cooling system, belt tension)
TWAY	3-way system (electronic control unit, O_2 sensor, other components associated with the 3-way catalyst system)

Appendix E

Probable Causes of High FTP Emissions for Nine Selected Vehicles

Veh #	FTP HC (g/mi)	FTP CO (g/mi)	FTP NO_x (g/mi)	Probable Causes
103	14.20	23.76	2.97	(HC) High resistance in spark plug wires and one of them was not connected.
105	3.70	33.27	2.08	(HC/CO) Idle mixture rich, vacuum advance diaphragm leaks.
107	3.10	34.23	6.16	(HC/CO) Choke two notches rich. (NO_x) EGR diaphragm leaks.
112	4.85	22.43	1.23	(HC/CO) Idle mixture rich, timing -6 degrees, pulse air check valve leaking.
119	3.60	73.52	0.76	(HC/CO) Idle mixture caps missing, high off-idle CO concentrations indicate internal carburetor problems.
124	2.21	11.93	6.68	(NO_x) EGR valve stuck closed.
130	4.47	63.79	2.72	(HC/CO) Idle mixture caps missing, idle speed +260, spark plugs misfiring, (NO_x) EGR passage plugged.
143	4.01	37.74	5.65	(HC/CO) Initial timing +4 but unable to identify more likely cause. (NO_x) Unable to identify cause.
149	5.68	84.18	1.25	(HC/CO) Timing -4 degrees. Internal carburetor problems suspected.